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PROBLEMS OF BULK STORAGE AND THE PROSPECTS OF NEW TECHNIQUES IN THIS FIELD: MINISTRY OF FOOD AND AGRICULTURE

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UNITED NATIONS CONFERENCE
ON
THE APPLICATION OF SCIENCE AND TECHNOLOGY
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Agenda Item: D-4: Problem of Bulk Storage and the prospects of new techniques in this field (Ministry of Food and Agriculture).

by
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Bulk storage of agricultural produce particularly the foodgrains has been a common practice in India due to seasonal nature of production, uncertain harvests and a year round demand for cereals which constitute the bulk of the food. Visitations of famines, locusts, droughts and floods had also to be combated with by maintaining sufficient stocks on hand. A number of techniques and methods of storage got developed in the past for maintaining over a time bulk stocks of foodgrains and similar agricultural commodities. Some of them continue to remain in vogue and are known as 'conventional' methods. Any discussion on the prospects of the new techniques will have to take into account the background of conventional techniques.

Conventional methods of bulk storage prevalent in India:

(a) Underground storage has been one of the most common techniques followed for the storage of a number of commodities like foodgrains, some of the spices and even oilseeds. This technique comprises an excavation in the ground and keeping the produce covered with earth in its most elementary form. In the modern shape a structure built in masonry and covered with concrete so as to make it fairly airtight is being used. In between these, structures built with unbaked or baked bricks, plastered with mud or lined with water-proof materials are also in use. This storage is invariably considered to keep the commodity free of pest attacks and thefts. In practice thefts are guarded against but not the pest attacks, probably as the stores are not sufficiently airtight. Under this system once the storage is sealed with a commodity filled in, it could be opened only during the fair weather and, once opened, has to be emptied without any loss of time. This limits the utility of this type of storage for maintaining bulks.

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(b) Where underground structures were not possible on account of water seepage, above-ground structures comprising of simple construction made out in either mud, straw or wood and lately in brick and concrete got developed. Commodities are either stored in sacks or loose. These structures do not offer protection from pests and moisture but have become popular on account of low cost and the ease with which stocks can be moved in and out.

The various types of indigenous storage structures known by different names in different parts of the country may be classified as shown at Table I.

The structures described above served the purpose in the past when agricultural commodities were available in large quantities and some spoilage was taken for granted. With the industrial development, transport facilities, increase in per capita income and quality consciousness, losses have assumed significance. Further, with the introduction of money economy and provisions to protect the producers vis-a-vis the consumers, the stabilisation of prices of the agricultural products has become an important objective of the storage programmes. For holding large reserves to achieve stable conditions, the conventional methods being adopted impose limitations, the most important being maintenance of quality.

No systematic data regarding losses to grain stored conventionally are available, but on account of the very favourable conditions for deterioration in India, these are considered to be high. With the efforts to step up production, mouths to be fed are also ever increasing, which necessitates making every effort to conserve whatever is produced. In the previous two 'Five-Year Development Plans' of the country, stress had been laid on increase of the production of all the important agricultural commodities. Foodgrains (cereals and pulses) production in India was of the order of about 76 million tons during 1960-61. By 1965-66 it is estimated that 100 million tons of foodgrains need be produced (rice - 45 million tons, wheat - 15 million tons, other cereals 23 million tons and pulses 17 million tons). In the situation it has become necessary both from the point of view of conserving whatever is produced and from the point of stabilisation of the prices, to maintain bulks of foodgrains. A beginning has also been made by proposing to hold a bulk of 5 million tons of foodgrains and a target of about 3 million tons has already been reached. At present mainly imported grains are used for maintaining the bulk but the indigenous grains will be used as soon as production reaches the target level by 1965-66.

The bulk of foodgrains now being maintained as a price lever and known as 'buffer stock' is distributed all over the country in a number of centres. In selecting a centre, a number of aspects have been considered - such as the demand in the area over a number of years, period for which foodgrains could be held safely and the likely turnover in relation to demand, effect on the market in case large quantities are to be off-loaded from storage on account of deterioration, facilities of transport and for handling and the source of supply.

Types of resources:

In general the cereal crops are harvested by hand in India. It

has certain advantages such as the crops get thoroughly dried to a safe limit of moisture content of 8 to 10%, qualities remain separate and individual attention is paid to various blocks in which a particular variety of crop is grown. Since the process is very slow, many a risk are also attendant on this. Very often the cereals get damaged in the threshing floors due to rains, hail storms and fire. Over and above this, cereals get insect infestation (Sitophilus oryzae L, Rhizopertha dominica F, and Sitotroga cerealella O) in the field.

Indian climate is very conducive for the development and multiplication of microflora. Their activities are further enhanced by the presence of insects in the cereals. Throughout the year the insects and the microflora if attack is initiated in the field would flourish in the grain causing a substantial damage. Regarding the storage fungi, there is evidence that so long as the seeds remain attached to the rachis and surrounded by glumes, they are much less susceptible to invasion by storage fungi than the kernels that are threshed out. Complex of conditions influences the invasion of stored grain by insects and fungi and in practice these operate together. The major ones are moisture content, temperature, amount of previous infestation, time and the activities of various grain inhabiting insects and mites.

Storage and handling in jute bags of all the farm commodities is the standard method now in vogue in the country. For the sake of facility of handling and cheapness, the use of bags in almost all stages like transport storage, long distance movement and marketing etc. is being practised. But it presents no barrier to the entry of insects, rodents, moisture, contaminants etc. Keeping in view the facility for fumigation, stacks measuring 30 x 20', 18 to 20 bag high consisting of 1500 to 1600 bags each containing 93 kgs. of wheat are kept in Government controlled warehouses. The cost involved for control operations and handling comes to be relatively high as compared to handling same quantity of grain in a loose condition. Moreover, bagged storage poses a problem for checking the quality of grain and for scientific inspection while loose storage is advantageous for these reasons, the most convincing being the ease in handling and inspection. Two silos have been erected in the country recently which highlight the difference between bulk and bag handling. Plans to get more bulk stores particularly of the 'flat type' constructed in the country, machinery for weighing, drying etc. are afoot. These constructions are further being undertaken at central places with a view to hold large bulks at strategic points. Considerable progress has been made in this direction already and experience bears out the anticipations of the scheme. Besides foodgrains, bulk storage of fruits and vegetables, specially potatoes and peas, is being successfully planned and carried out in the country.

Although bulk-storage of perishables, such as fruits and vegetables, will be associated with the problem of heat generation, tissue injury and microbial spoilage, the technique of field-spraying with hormone and surface coatings with fungicidal composition and wax emulsion have been tried and found to give an extended storage life to these commodities. In conjunction with the temperature and humidity control of the warehouse, the above pre-treatments are seen to offer better scope for reducing spoilage during their transit and storage.

Fruits, vegetables and other perishable commodities contain high moisture and are metabolically very active. The bio-chemical activities in tissues remain at a high level during the post-harvest storage, these offer special problems relating to the high catabolic activities and tissue deterioration due to autolysis and activities of pathogenic and saprophytic microflora. Adequate ventilation, temperature and humidity controls of the environment and restriction of the depth of the bulk became essential for extending storage life. Fungicidal treatment for the control of fungi, wax-coating for preventing transpiration, hormone treatment for modifying the metabolic pathways, have been tried and found helpful for enhancing the shelf life of the fruits and vegetables. Every fruit and vegetable is observed to require different optimum conditions and treatments for the maximum storage life and these have been worked out. Several aspects of the storage and post-storage behaviour of refrigerated, cold and cool storages have been investigated with most of the major fruits and vegetables in India. Besides safe and sound conservation of farm produce, its transport from production centres to consumption centres plays an important role in the food economy of the country and this is also receiving attention.

Transport problems:

Due to dearth of power and limited capacity of the farmers to go for power transport, the primitive method of carrying the farm produce over short distances in head-loads continues. For bringing the produce to the market centres, bullock-carts, donkeys, camels, manual labour etc. are being used in different regions of the country depending on terrain and distance. Road and rail transport is limited and herein mainly bagged cargo is transported from one place to another. Efforts are being made for loose transport of an imported commodity like grain but on a large scale it has not been possible so far. Commodities move from production centres to consumption centres and sometimes there is nothing to be loaded from consumption centres to other places and empty haulage poses a problem. Possibility of making multi-purpose wagons is under the active consideration. Presently there are no special rail wagons for transport of the agricultural commodities and these have to be carried in sacks in all-purpose wagons.

In commercial stores bagged grain keeps well for about 6 months at the port towns, while in the interior centres it keeps for about 12 months. When the facilities for loose grain storage are provided, the storability of grain is expected to be further increased. Only rice might offer some difficulties for loose storage but according to recent works this also seems possible.

Marketing facilities:

Out of a few thousand markets in the country, only 521 are regulated and of these about 300 are regulated for foodgrains. Buyers fix the price on sample basis and keeping in mind the likes and dislikes of the populace of the area. In the absence of a national grading system, it becomes very difficult to get a product of a uniform quality which is so necessary for bulk storage. Presently the Government have drawn up national grades for various foodgrains and this should facilitate grade-wise selling and make bulk storage easier.

Mechanical handling:

This has been provided in a few centres and experience relating to it is satisfactory. Mechanisation, however, is loudly resented by the labour and the general conversion has to be gradual and such as not to affect a large scale unemployment. The large bulks are appropriate for mechanisation and this is planned in the future construction programmes.

Underground storage supposed to be airtight has been followed in the country from time immemorial. It has recently been suggested that the use of airtight structures would overcome most of the difficulties of storage. This suggestion has much to recommend in it. But the airtight bins do not permit storage of damp material, for recent work has shown that the condition known as 'sickness' is developed under these conditions. Also airtight storage does not reduce the troubles which arise from sharp temperature gradients and surface condensation in climates where temperatures change rapidly. Amongst the claims made for airtight are that it prevents the entry of insects, rodents and ultimately kills any, which the grain may have originally contained, it prevents the uptake of moisture from the atmosphere during storage and it may reduce the rate of onset of fat acidity. The airtight storage deserves thorough trial in hot countries provided that grain can be harvested dry or where drying facilities exist. It is possible that the underground pit type of store which is commonly found in the country is in fact nearly airtight and the success of such stores should be the testimony to the efficacy of nearly airtight stores.

Nuclear control:

Because of a very low cost as compared to other chemical methods of control, efforts are being made by the Atomic Energy Commission of India to evolve a safe and cheap method of storage pests control by using nuclear energy. This is, however, conditional. If human health hazards are involved, this won't be feasible. Secondly, so long as mechanical handling is not adopted in general, it may not be possible to use nuclear energy for control purposes, because the whole operation has to be done at a speed which pre-requires the handling of grain mechanically.

Temperature in relation to insect infestation:

Studies show that heat moves through many of the agricultural commodities very slowly indeed. Vast amount of data have made it possible to calculate that diurnal temperature changes penetrate only about 6" into the bulk grain, while even natural temperature cycle from summer to winter is negligible at depths of 10'. The detection of deterioration through measurement of heat produced alone, however, is really a tricky problem. Essentially the insects are able in certain circumstances to induce hot spots by producing metabolic heat faster than it can escape from their immediate environments. Most grain pests are of tropical and sub-tropical origin. Their optimum temperatures lie between 28°C and 35°C and their maxima being usually 33°C and 40°C. Thus it is clear that grain should be kept at temperatures as far below the optima as possible. This is the difficulty in hot climates and it has been suggested as an alternative that attempts should be made to store grain at temperatures above the maxima quoted above. This theoretical possibility is almost certainly not practicable and would probably bring other serious troubles in its train. A number of other commodities are economically maintained

at low temperatures. Facilities of storage at controlled temperatures are being expanded every year. The optimum conditions necessary have already been worked out for most of the commodities.

Problems as an importing country: (Commercial aspects) -

Considerable portion of the bulk storage in India in respect of foodgrains is being built with imported grains. Quality assumes great significance as the exporter might be anxious to get rid of the surplus and the importer has to consider the problems of maintenance. Attitude of the importer is also considerably influenced by the standards of the public in the country. However, the fact that many countries have no import standards, has meant that goods rejected by the authorities for local consumption in exporting countries have been diverted elsewhere. This emphasises the need for a general raising of standards on the part of the principal importing countries.

It is clear that importing countries suffer losses and are put to a great deal of trouble in attempting to deal with infestation in imported foods. Much of this could be avoided if exporting countries control infestation before export. Today there can be no excuse, on technical ground, for the movement in international trade of infested commodities. Although proper facilities such as circulatory fumigation system or fumigation chambers are desirable, they are by no means essential, since fumigation of loose quantities is practicable under gas-proof sheets.

Thus what is needed is a greater demand specially by the importers of commodities that goods shall be un-infested on arrival. Competition between countries for markets for agricultural products has already caused certain exporting countries to lay down export quality standards and it is to be hoped that this tendency will spread. Pressure from importers is the most likely influence and this will not occur until they realise that infestation is not inevitable.

Research facilities:

Besides the Universities, Central Food Technological Research Institute, Mysore and Central Grain, Research & Training Centre, Hapur are imparting professional training covering all aspects of food technology. Hapur Institute is concerned with handling and inspection of grain and imparts training to the trainees sponsored by the State Governments and private bodies. Applied research is also undertaken to solve day-to-day problems regarding grain storage. Assessment of storability and working out of cheaper methods for pest control are some of its achievements.

Training, Future requirement and Research:

Training to personnel in engineering aspects of grain storage is being imparted in the country as well as technical personnel are being sent to obtain training in various disciplines of engineering of grain handling in Canada, U.S.A., U.K., etc.

There is a great need for intensifying research programmes in a scale which will minimise the lapse between the laboratory and field application. The techniques which have been developed recently in the

field of grain storage, need extended application and assessment, under field conditions in all the countries, where similar situations prevail.

Further research on the following lines is proposed:

(a) Comparative trials on the selection of the new types of structures developed in other countries for their suitability under Indian conditions. Structures like the Fossae in Malta, Plywood silo of Sierra Leone, Plastic-lined metal bin as has been used in U.S.A.,Ctosiphon structure of Kano, Khattis and Kothas of India, hemispherical grain silo of novel design of Jordan, underground semi-circular vaults of Argentina and modern mechanised silo-cum-elevators, should be studied for their suitability under the regional conditions.

(b) Technological aspects of fumigants and fumigations, with special reference to their application in silos, elevators, bins, warehouses, flat stores, farm barns, etc., need intensive studies in view of the high temperature conditions. The fumigants of high boiling point and low vapour pressure require critical assessment under the conditions of storage installations, structure and environmental temperatures. Application techniques and degassing and recirculatory equipment suitable for applications under the practical situation are to be developed. Enlarged facilities for technological training on fumigation, will have to be provided urgently.

(c) Ecology of the insect pests in bulks, with special reference to their habit, habitat, movement and distribution of life stages, with a view to devising simple methods for their control, based on the vulnerable features in the life history and behaviour, would be studied.

(d) Bulk-handling techniques and equipment should be developed and employed. Small-scale and large-scale handling techniques at every stage of processing, transport and storage are to be standardised. Drying techniques for bulk and moisture equilibrium in tall and large structures, will have to be developed.

(e) The criteria for predicting the soundness or storability of the grain and assessing the degree of infestation and microbial load which can be readily applied by grain storage establishments, are to be developed for different grains.

Keeping in view the expanded programme for storage in the coming years, bulk storage is a MUST under Indian conditions. The 'Third Plan' has allotted Rs.25 crores for the construction of additional warehouses by the Government for the storage of foodgrains and Rs.8 crores for warehousing programmes of other commodities. The provisions of storage capacity is a vital step in the implementation of price policy under the Plan and such further resources, as may be needed, are to be made available. Of course, the storage of grain in bulk involves special problems which have been studied fairly and intensively during the recent years. Much more is now known than was the case when it was decided to set up reserve stocks of grain in the country. For example, in the field of behaviour of insects, various species act in very different ways - some cannot be detected until they have caused damage (e.g. Laemophloeus beetle in the midst of bulk), and others can at times cause alarm out of proportion to the damage which they do (e.g. Caterpillar of Ephestia at the migratory stage).

In the bulk stores now being planned, new techniques are constantly

under examination and experimentation. We have found under improvised loose grain storage that the quality of grain remains satisfactory and insect infestation remains limited to the periphery. Environmental moisture prevailing in the vacinity of the grain does not affect the internal core of the loose grain as happens in case of bagged grain. The problem of rat and mite infestation will become extinct with the modern rat-proof stores for loose grain in bulk. On the whole, it can be said that modern bulk storage is in the process of evolution in India and prospects of using new techniques are bright.

Table - I.

Local names of indigenous storage structures

	Underground	Aboveground
(1)	'Khattis ' - 15' dia. 16' ht. 15-25 tons bhoosa (husk) lined-mud plastered.	'Petti' - boxlike mud bins
(2)	'Banda' - 15' deep Convex Covering.	'Bharolas' - 3' ht. mud bins.
(3)	'Pev' - Underground godown.	'Bukhari' - 8-10 tons chambers built against wall.
(4)	'Targhars' - Cellers with lid-like doors.	Cement bins - 20-100 tons.
(5)	Khas-well-like, with stone.	Straw bins: 'Paras', 'Mudhas' 'Muras', 'Pattari' 'Pallas', 'Thekas'
(6)	'Khais' - Mud or cement - Bhoosa (husk) lined - 20 to 40 tons.	Earthen receptacles - baked and unbaked.
(7)		Metal receptacles.

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